## A.5. VENTILATION SYSTEMS

Safety issue description: these cases illustrate the typical issue of upgrading ventilation systems in existing tunnels to meet safety objectives. This would be the case where the existing tunnel has been constructed prior to the regulation update or an assessment of significant changes in terms of traffic has been made.

### A.5.1. Example for simple unidirectional tunnel with 2 tubes

**Tunnel situation:**
- unidirectional tunnel 2 tubes,
- existing ventilation system: longitudinal,
- traffic increase and fire conditions require more air flow or higher air flow velocity,
- solution: add additional fans.

**Construction conditions:**
- new fans may be installed during short tunnel closures,
- complementary power supply may be installed during night with one lane closed,
- modification of SCADA, may be tested during low traffic period.

**Alternative solutions:**
- alternatively, but most costly, Saccardo nozzles can be implemented at portals or fan rows at portals in elevated crown,
- intermediate shafts, especially for urban tunnels,
- according to the length, smoke exhausts at intervals may be required.

**Operational consequences:**
- emergency Response Plan adaptation (access of rescue team).

In case of a complex situation (e.g. regular traffic jams, ramps in the tunnel etc.), further refurbishment requirements would be required, e.g.:

- control and management of longitudinal airflow,
- particular consideration of aspects such as work phasing and corresponding refinement of emergency plans and operating conditions.

**Tunnel situation:**
- unidirectional tunnel 2 tubes,
- existing ventilation may be longitudinal or semi transverse,
- numerous traffic jams,
- particular atmospheric conditions at portal, with strong natural air flow inside the tunnel.

**Refurbishment requirements:**
- control and manage longitudinal air velocity,
- Create or keep smoke extraction (smoke exhaust, dampers).

**Civil works implications:**
- investigation of all possible conditions,
- very detailed construction method analysis, in order to target construction time with precision of less than one day,
- strategy of works staging with regard to closure possibility,
- in case of staging – evaluation of the safety conditions when temporary reopening between two construction stages,
- tight survey and control of the upgrade works in order to respect the programme.

**Solutions for controlling air velocity:**
- the implementation of boosters at each portal;
- the installation of jet fans or injectors:
- build recess to install jet fans,
- adapt the power supply and the data transmission network,
- modify the SCADA;
- organisation of upgrading works:
- civil for recess needs closure of the tube,
- other works as for previous example.

It may also be the case that the ventilation control system is not automated or implemented. In some of these cases, if a specific ventilation response is required, an operator has to instigate manually; or the ventilation control requires detailed information from sensors that require upgrade. Also, in some existing tunnels it may be necessary to upgrade the fans in order to increase their fire resistance.

### A.5.2. Ventilation control

**Objective:**
- to provide or improve the automatic ventilation control during normal operation and in case of a fire emergency.

**Construction conditions:**
- anemometers may be required;
- study of the fans' real thrust and its reaction time;
- real scale tests would require tunnel closure for short periods, preferably at night or during low traffic periods;
- low impact for users;
- SCADA modifications.

**Operational consequences:**
- emergency Response Plan adaption;
- SCADA modification.

### A.5.3. Pollution sensors and anemometers

**Objective:**
- to equip the tunnel with a higher number of pollution sensors and anemometers;
- to increase the information about the air quality inside the tunnel and improve the resilience of the system to a sensor failure.

**Construction conditions:**
- new devices can be installed during a very short lane closure;
- this can be carried out at night or during low traffic periods;
- very low consequences for users;
- requires SCADA modifications;
- it may require changes in signal acquisition devices.

**Operational consequences:**
- maintenance;
- SCADA modification (new signals).

### A.5.4. Heat resistance of fans

**Objective:**
- to equip the tunnel with heat resistant fans;
- includes cable protection if necessary.

**Construction conditions:**
- fans can be replaced during short tunnel closures;
- SCADA must be tested;
- low impact for users;
- low consequences on traffic;
- temporary reinforcement of signalling and patrol;
- test during low traffic periods.

**Operational consequences:**
- maintenance;
- Emergency Response Plan adaption.